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[List of File Documents]

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[Document Name] SPECIFICATION

[TITLE OF THE INVENTION] MAGNETIC TRANSFER APPARATUS

[CLAIMS]

[Claim 1] A magnetic transfer method, comprising bringing a magnetic transfer master having a magnetic film formed on at least one side into close contact with a magnetic disk, and magnetically transferring a pattern of the magnetic film of the magnetic transfer master onto the magnetic disk through application of an external magnetic field, the method including an examination step for detecting defects in a disk, wherein

after a surface of a cleaning disk is examined in the examination step and thereby it has been confirmed that the number of defects or a size of the defects is not greater than a predetermined value,

an operation in which the magnetic transfer master is brought into close contact with and separated from the cleaning disk is repeated a predetermined number of times, and

the magnetic transfer master then is brought into close contact with the magnetic disk and magnetic transfer is performed.

[Claim 2] A magnetic transfer method, comprising bringing a magnetic transfer master having a magnetic film formed on at least one side into close contact with a magnetic disk, and magnetically transferring a pattern of the magnetic film of the magnetic transfer master onto the magnetic disk through application of an external magnetic field, the method including an examination step for detecting defects in a disk, wherein

after an operation in which the magnetic transfer master is brought into close contact with and separated from a cleaning disk is repeated a predetermined number of times,

the magnetic transfer master is brought into close contact with a detection disk, the detection disk having been examined by the examination step to confirm that the number of defects or a size of the defects on a surface that comes into contact with the magnetic transfer master is not greater than a predetermined value, and

the detection disk is then subjected to defect detection by the examination step, and when the number of defects or a size of the defects on the surface is not greater than a predetermined value,

the magnetic disk and the magnetic transfer master are brought into close contact with each other and magnetic transfer is performed.

[Claim 3] A magnetic transfer method, comprising bringing a magnetic

transfer master having a magnetic film formed on at least one side into close contact with a magnetic disk, and magnetically transferring a pattern of the magnetic film of the magnetic transfer master onto the magnetic disk through application of an external magnetic field, the method including an examination step for detecting defects in a disk, wherein

after an operation in which the magnetic transfer master is brought into close contact with and separated from a cleaning disk is repeated a predetermined number of times, the cleaning disk having been examined by the examination step to confirm that the number of defects or a size of the defects on a surface that comes into contact with the magnetic transfer master is not greater than a predetermined value,

the magnetic transfer master then is brought into close contact with a detection disk, the detection disk having been examined by the examination step to confirm that the number of defects or a size of the defects on a surface that comes into contact with the magnetic transfer master is not greater than a predetermined value, and

the detection disk is then subjected to defect detection by the examination step, and

when the number of defects or a size of the defects on the surface is not greater than a predetermined value, the magnetic disk and the magnetic transfer master are brought into close contact with each other and magnetic transfer is performed.

[Claim 4] A magnetic transfer method, comprising bringing a magnetic transfer master having a magnetic film formed on at least one side into close contact with a magnetic disk, and magnetically transferring a pattern of the magnetic film of the magnetic transfer master onto the magnetic disk through application of an external magnetic field, the method including an examination step for detecting defects in a disk, wherein

after the pattern of the magnetic film of the magnetic transfer master is magnetically transferred onto the magnetic disk,

the magnetic disk is subjected to defect detection by the examination step, and when the number of defects or a size of defects is equal to or greater than a predetermined value, an operation in which the magnetic transfer master is brought into close contact with and separated from a cleaning disk is repeated a predetermined number of times.

[Claim 5] The magnetic transfer method according to claim 1, 2, or 4, wherein the operation in which magnetic transfer master and cleaning disk

are brought into close contact with or separated from each other is performed by evacuating a gas between the magnetic transfer master and cleaning disk or by introducing a gas between the magnetic transfer master and cleaning disk.

[Claim 6] The magnetic transfer method according to claim 1, 2, or 4, wherein the magnetic transfer master is harder than the magnetic disk and the cleaning disk.

[Claim 7] The magnetic transfer method according to claim 1, 2, or 4, wherein the cleaning disk is softer than the magnetic disk.

[Claim 8] The magnetic transfer method according to claim 1, 2, or 4, wherein a region where there is contact between the magnetic transfer master and the cleaning disk includes a region where magnetic transfer is performed from the magnetic transfer master to the magnetic disk.

[Claim 9] The magnetic transfer method according to claim 1, 2, or 4, wherein the master disk and the cleaning disk having no lubricant applied thereto are brought into close contact with and separated from each other repeatedly, so that foreign matter on the master disk is removed.

[Claim 10] The magnetic transfer method according to claim 1, 2, or 4, wherein the cleaning disk has a plating layer on its surface.

[Claim 11] The magnetic transfer method according to claim 10, wherein the plating layer has magnetic characteristics.

[Claim 12] The magnetic transfer method according to claims 1 to 11, wherein the surface of the magnetic disk is subjected to defect detection by the examination step before magnetic transfer is performed, and immediately after confirming that the number of defects or a size of the defects is not greater than a predetermined value, the magnetic disk and the magnetic transfer master are brought into close contact with each other and magnetic transfer is performed.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[Technical field to which the invention pertains]

The present invention relates to a magnetic transfer apparatus that performs magnetic transfer in a process of manufacturing a magnetic disk used in hard disk drives or floppy disk drives.

[0002]

[Prior Art]

Currently, magnetic recording/reproduction apparatuses are on a

trend toward higher recording densities with the aim of producing small, high-capacity apparatuses.

[0003]

A representative magnetic disk drive is a hard disk drive. Hard disk drives with areal recording densities in excess of 10 GBit/in^2 already have appeared on the market, with practical use of drives having an areal recording density of 20 Gbit/in^2 being expected in the next few years due to the rapid technological advancements being made in this field.

[0004]

A major technical factor in the achievement of such high recording densities is the use of magneto-resistive element type heads that not only allow increases in linear recording density but also can reproduce, with a favorable S/N ratio, a signal recorded on a track no wider than a few microns.

[0005]

The increases in recording density also have made it necessary to reduce the distance that a floating magnetic slider floats above a magnetic recording medium. This increases the probability of the slider coming into contact with the disk for some causes even while the slider is floating. Such a situation requires recording media to have a further smooth surface.

[0006]

Tracking servo technology used in a head plays an important role in having a head precisely scan a narrow track. A modern hard disk drive that employs such tracking servo technology uses areas where tracking servo signals, address information signals, reproduction clock signals, and the like are recorded that are provided on a magnetic recording medium at intervals of a predetermined angle (hereinafter referred to as "preformat recording"), and a drive apparatus detects the position of the head based on these signals that are reproduced by the head at predetermined time intervals, and corrects the head position, so that the head can properly scan a track.

[0007]

As described above, the servo signals, address information signals, reproduction clock signals, and the like are used as reference signals for having the head properly scan tracks. Hence, high positional accuracy is required when writing (hereafter referred to as "formatting") these signals. In current hard disk drives, formatting is carried out with the recording

head being positioned using a dedicated servo apparatus (hereafter referred to as a "servo writer") equipped with a highly precise position detecting apparatus that uses optical interference.

[0008]

However, formatting using the aforementioned servo writer has the following problems.

[0009]

First, recording by a magnetic head is linear recording that basically is made through the relative movement between the magnetic head and the magnetic recording medium. Since it is necessary to record signals on a large number of tracks, preformat recording by a method using a servo writer takes a long time. In order to make manufacturing more efficient, a plurality of expensive, dedicated servo writers are required, making the preformat recording very costly.

[0010]

Secondly, the implementation and maintenance of many servo writers incur a high cost. These problems become more serious as the track density and the number of tracks increase.

[0011]

Hence, a method has been proposed that does not use servo writers to carry out formatting. With this method, a disk called a "master" on which all of the servo information has been pre-recorded is placed on top of the magnetic disk to be formatted and energy to achieve transfer is applied from an external source to transfer all of the master information onto the magnetic disk simultaneously.

[0012]

One example of this technique is the magnetic transfer apparatus described in Publication of Unexamined Japanese Patent Application JP H10-40544A.

[0013]

This publication discloses the following method. A magnetic portion made from a ferromagnetic material is formed on a substrate surface in a pattern corresponding to information signals, thereby producing a master information carrier. The surface of this master information carrier is brought into contact with the surface of a sheet-shaped or disc-shaped magnetic recording medium provided with a ferromagnetic thin film or an applied layer of a ferromagnetic powder. A predetermined

magnetic field is then applied thereto, so that a magnetic pattern having a pattern form corresponding to the information signals formed on the master information carrier is recorded on the magnetic recording medium.

[0014]

[Problems to be solved by the invention]

In recording information signals using such a conventional magnetic transfer apparatus, the above method is used in which all the arrangement of patterns corresponding to the information signals on the master information carrier is recorded onto the magnetic recording medium as magnetic patterns simultaneously. In this method, however, it is important to have the high density information signals recorded uniformly and with high stability across the entire surface of the magnetic recording medium.

[0015]

In the above-mentioned conventional magnetic transfer apparatus, however, when unwanted protrusions or foreign matter are present on the surface of a magnetic recording medium 5 or on a convex part 6 of a master information carrier 4, depressions appear in the surface of the magnetic recording medium due to the contact between the two.

[0016]

FIG. 12 shows a surface shape of the magnetic recording medium 5 after the magnetic recording medium 5 and the convex part 6 of the master information carrier 4 are brought into contact with each other according to a conventional magnetic transfer method. The circle marked at the center shows a depression formed by an unwanted protrusion. FIG. 13 shows a graph produced by measuring a cross-section of this depression.

[0017]

In FIG. 13, the depression has a depth of about 50 nm from the surface of the magnetic recording medium, and is surrounded by a minute protrusion that is about 20 nm high.

[0018]

A slider floats about 20 nm above the surface of a magnetic recording medium. If a magnetic recording medium has protrusions that are about 20 nm high such as one shown in FIG. 12 (13), the magnetic head will come into contact with the magnetic recording medium during the recording and reproduction of data. In such a case, at the instant when this happens, the magnetic head is forced upward, increasing the clearance between the magnetic head and the magnetic disk and deteriorating the

signal recording/reproduction performance. Also, physical contact between the magnetic head and the magnetic disk shortens the life of the magnetic head and can lead to failures of the magnetic recording medium itself.

[0019]

FIG. 14 is a depiction showing results of optical measurements carried out for protrusions on the entire surface of a magnetic recording medium that has been subjected to magnetic transfer by such a conventional magnetic transfer method. It can be seen that a large number of protrusions with a height of 20 nm or higher are present on the surface of the magnetic recording medium.

[0020]

As described above, according to conventional magnetic transfer methods, there are a large number of protrusions present on the magnetic disk. This causes the problems of lower recording/reproduction performance and a shorter lifespan of a magnetic head. If the future movement towards higher recording densities is accompanied by a reduction in the distance that a magnetic head floats above a disk, these problems will become more serious.

[0021]

With the above-mentioned conventional problems in mind, the present invention is intended to achieve highly reliable magnetic transfer that causes no minute protrusion to appear on a magnetic disk.

[0022]

[Means for solving problems]

In order to solve the above-mentioned conventional problems, a magnetic transfer apparatus of the present invention brings a magnetic transfer master having a magnetic film formed on at least one side into close contact with a magnetic disk, and magnetically transfers a pattern of the magnetic film of the magnetic transfer master onto the magnetic disk through application of an external magnetic field,

wherein after an operation in which the magnetic transfer master is brought into close contact with and separated from a cleaning disk is repeated a predetermined number of times, the cleaning disk having been examined, by a disk defect detecting means, to confirm that the number of defects or a size of the defects on the disk surface that is brought into close contact with the magnetic transfer master is not greater than a predetermined value, the cleaning disk is replaced by the magnetic disk, the

magnetic disk and the magnetic transfer master are brought into close contact with each other, and thereby magnetic transfer is performed. This makes it possible to quickly and reliably remove foreign matter that is adhering to the magnetic transfer master.

[0023]

A magnetic transfer apparatus of the present invention brings a magnetic transfer master having a magnetic film formed on at least one side into close contact with a magnetic disk, and magnetically transfers a pattern of the magnetic film of the magnetic transfer master onto the magnetic disk through application of an external magnetic field,

wherein after an operation in which the magnetic transfer master is brought into close contact with and separated from a cleaning disk is performed, the magnetic transfer master is brought into close contact with a detection disk, the detection disk having been examined, by a disk defect detecting means, to confirm that the number of defects or a size of the defects on a disk surface that comes into contact with the magnetic transfer master is not greater than a predetermined value, and

after the detection disk then is examined, by the disk defect detecting means, to confirm that the number of defects or a size of the defects on the disk surface that came into contact with the magnetic transfer master is not greater than a predetermined value, the detection disk is replaced by the magnetic disk, the magnetic transfer master is brought into close contact with the magnetic disk, and thereby magnetic transfer is performed. This allows defects in the magnetic transfer master to be detected very easily with high accuracy. Hence, a highly reliable magnetic transfer disk can be provided.

[0024]

A magnetic transfer apparatus of the present invention brings a magnetic transfer master having a magnetic film formed at its surface into close contact with the surface of a magnetic disk at which a ferromagnetic film is formed, carries out a step of magnetically transferring a pattern of the magnetic film of the magnetic transfer master onto the magnetic disk surface through application of an external magnetic field, then detects defects in the magnetic disk by a defect detecting means, and when the number of defects or a size of defects is equal to or greater than a predetermined value, an operation in which the magnetic transfer master is brought into close contact with and separated from a cleaning disk is

repeated a predetermined number of times, whereby foreign matter that is adhering to the magnetic transfer master is removed. This makes it possible to easily and quickly judge whether foreign matter is adhering to the magnetic transfer master and remove it. Thus, highly reliable magnetic transfer can be achieved.

[0025]

[Mode for carrying out the invention]

The following describes an embodiment of the present invention with reference to the drawings.

(First Embodiment)

The following describes a magnetic transfer apparatus and a method of manufacturing a magnetic recording medium according to the embodiment of the present invention, with reference to FIGS. 1 to 11.

[0026]

FIG. 1 is a flowchart showing steps for performing magnetic transfer according to the embodiment of the present invention.

[0027]

First, a magnetic transfer master is described.

[0028]

FIG. 2 is an enlarged view of part of a magnetic transfer master 2 according to the embodiment of the present invention, which is used for explaining the configuration of the magnetic transfer master 2. In FIG. 2, numeral 30 indicates a magnetic film that is used for transferring a magnetic pattern onto a magnetic disk 1. A master information pattern is formed on the magnetic film 30, in a pattern corresponding to the digital information signals to be recorded on the magnetic disk 1. This master information pattern is formed in a magnetic portion made of a ferromagnetic thin film. Various types of magnetic materials such as hard magnetic materials, semihard magnetic materials, or soft magnetic materials can be used for the ferromagnetic thin film. Any material may be used as long as it enables a digital information signal to be transferred and recorded on the magnetic recording medium. As examples, iron, cobalt, or an alloy of iron and cobalt may be used.

[0029]

In order to produce a sufficient magnetic field for recording regardless of the type of the magnetic disk 1 on which the master information pattern is to be recorded, the saturation magnetic flux density

of the magnetic material should be as high as possible. In particular, for magnetic disks that have a high coercivity in excess of 2000 oersted, or flexible disks with a thick magnetic layer, there are cases where a saturation magnetic flux density of 0.8 tesla or below is not sufficient for recording to be performed properly. For this reason, a magnetic material with a saturation magnetic flux density of 0.8 tesla or above, or preferably 1.0 tesla or above, is used in general.

[0030]

Numeral 4 indicates radial grooves that are provided on the transfer surface 3 at which the magnetic film 16 of the magnetic transfer master 2 is provided. With respect to the magnetic transfer master 2 with such a configuration, as shown in step ST1 in FIG. 1, the magnetic transfer master 2 is washed by a well-known method, for example, scrubbing. However, it has been found by experimentation that using a conventional washing method, it is not possible to remove minute foreign matter whose sizes range from about 20 to 50 nm that remains on the transfer surface 3 of the magnetic transfer master 2. Step ST2 that is carried out for removing minute foreign matter reliably is described with reference to FIGS. 3 and 4.

[0031]

FIG. 3 is a cross-sectional drawing of the apparatus, showing step ST2 according to the embodiment of the present invention, particularly a separating means. FIG. 4 is a cross-sectional drawing of the apparatus, showing step ST2 according to the embodiment of the present invention, particularly a pressing means.

[0032]

In FIG. 3, numeral 1A indicates a cleaning NiP disk, while numeral 2 indicates a magnetic transfer master disk that is pressed against the surface of the cleaning NiP disk 1A.

[0033]

Numeral 3 indicates a contact surface of the magnetic transfer master 2 that comes into contact with the cleaning NiP disk 1A. Grooves 4 that extend radially from the center of the magnetic transfer master 2 are provided in the contact surface 3. FIG. 5 is a drawing that shows the contact surface 3 of the magnetic transfer master 2 that comes into contact with the cleaning NiP disk 1A. As shown in FIG. 5, the grooves 4 extend radially from the center of the magnetic transfer master 2. In the present embodiment, the depth of the grooves 4 is set at about 5 μm. Numeral 5

indicates a boss that is fixed to the center portion of the magnetic transfer master 2. The boss 5 engages a center hole of the cleaning NiP disk 1A, and so centers the cleaning NiP disk 1A and the magnetic transfer master 2. Also, predetermined gaps 51 (see FIG. 6) are provided between the center hole of the cleaning NiP disk 1A and the boss 5, thereby allowing air to flow between them.

[0034]

In FIG. 3, numeral 6 indicates a support for supporting the cleaning NiP disk 1A. A through hole 7 is provided in the center of the support 6 to allow the passage of air. Numeral 8 indicates an air duct used for expelling air from between the magnetic transfer master 2 and the cleaning NiP disk 1A or pumping air between the two. Numeral 9 indicates an air exhaust outlet for expelling air from the air duct 8, numeral 10 indicates a suction pump that is connected to the air exhaust outlet, and numeral 11 indicates an exhaust valve that controls the expulsion of air. Numeral 12 indicates an air supplying pump for pumping air into the air duct 8, while numeral 13 indicates an air supplying valve for controlling the supplying of air. The air supplying pump 12 is provided with a 0.01-μm air filter, so that foreign matter with a size of at least 0.01μm is not pumped into the air duct 8. Numeral 14 indicates a holding arm that holds the magnetic transfer master 2. The magnetic transfer master 2 is held on the holding arm 14 by air that is sucked through a through hole (not illustrated) provided in the holding arm 14.

[0035]

First, the separating means is described with reference to FIG. 3. The suction pump 12 is operated with the exhaust valve 11 closed and the air supplying valve 13 open, so that air flows into the air duct 8. As a result, air is pumped through the through hole 7 upward, as shown by the arrow A in FIG. 3. The air that is pumped through the through hole 7 presses the boss 5 upward. Furthermore, air is pumped into the grooves 4, as shown by the arrows B. The air that is pumped into the grooves 4 spreads out radially towards the outer circumference from the center of the magnetic transfer master 2 through the grooves 4. The air then passes through the gap between the magnetic transfer master 2 and the cleaning NiP disk 1A from the grooves 4 and escapes to the atmosphere. This flow of air carries minute foreign matter that was adhering to the surface of the magnetic transfer master 2 or the cleaning NiP disk 1A to the atmosphere.

[0036]

FIG. 7 shows the relationship between the passage of time and the air pressure in the space (hereafter referred to as “space S”) between the magnetic transfer master 2 and the cleaning NiP disk 1A. As shown in FIG. 7, the air pressure in the space S sharply increases from a pressure of 101.3 kPa after the lapse of about 3 seconds, and thereafter, a pressure of about 130 kPa is maintained for about one second. This period corresponds to the above-mentioned state where the magnetic transfer master 2 and the cleaning NiP disk 1A are separated from each other.

[0037]

During this operation, it is preferable for the gap between the cleaning NiP disk 1A and the magnetic transfer master 2 to be set as narrow as possible. In the present embodiment, the gap is set at about 0.5 mm. This increases the speed at which air flows between the cleaning NiP disk 1A and the magnetic transfer master 2, ensuring that minute foreign matter present between the two is carried out to the atmosphere.

[0038]

Next, the pressing means is described with reference to FIG. 4.

[0039]

First, the air supplying pump 12 that was started in the above-mentioned separating means is stopped and the air supplying valve 13 is closed. Then, the suction of air to which the holding arm 14 is subjected is released, so that the magnetic transfer master 2 is separated from the holding arm 14. As a result, the magnetic transfer master 2 moves downwards by gravity, and thus the magnetic transfer master 2 is placed on the cleaning NiP disk 1A with the boss 5 engaging the center hole of the cleaning NiP disk 1A. After this, the exhaust valve 11 is opened and the exhaust pump 10 is operated. Consequently, air in the through hole 7 is expelled downwards as shown by the arrow C in FIG. 3. The air in the grooves 4 also is expelled through the gap between the center hole of the cleaning NiP disk 1A and the boss 5, resulting in the air pressure in the space of the grooves 4 that are covered by the cleaning NiP disk 1A falling below atmospheric pressure. Hence, the cleaning NiP disk 1A is pressed onto the magnetic transfer master 2 mainly by atmospheric pressure 15. As a result, foreign matter present on the magnetic transfer master 2 is sandwiched between the cleaning NiP disk 1A and the magnetic transfer master 2. When the cleaning NiP disk 1A and the magnetic transfer

master 2 are compared in hardness from each other, the cleaning NiP disk 1A is softer than the magnetic transfer master 2. Hence, foreign matter that is sandwiched between the two sinks into the cleaning NiP disk 1A or causes depressions in the cleaning NiP disk 1A, without damaging the magnetic transfer master 2. Minute unwanted protrusions present on the magnetic transfer master 2 are flattened when the magnetic transfer master 2 is pressed against the cleaning NiP disk 1A. In FIG. 7, the period during which the air pressure in the space S is about 30 kPa corresponds to the above-mentioned state where the two are pressed together.

[0040]

Next, the separating means shown in FIG. 3 is repeated. That is to say, the exhaust valve 11 is closed, the air supplying valve 13 is opened, and the air supplying pump 12 is operated. This results in air being pumped as shown by the arrows A and B in FIG. 3. The magnetic transfer master 2 is moved upward by the air pumped in this way and stops when coming into contact with the holding arm 14. At this point, air passes through the grooves 4 and continues to be pumped radially towards the outer circumference from the center of the magnetic transfer master 2, as shown by the arrows B. As a result, foreign matter that was present on the surface of the magnetic transfer master 2 is expelled to the atmosphere together with the air pumped by the air supplying pump 12, or is transferred onto the cleaning NiP disk 1A. By repeating the pressing together and separating operations a predetermined number of times, foreign matter present on the surface of the magnetic transfer master 2 can be removed.

[0041]

It is preferable that the cleaning disk is not coated with a lubricant. This is because the ability of the cleaning disk to absorb foreign matter is reduced when lubricant is applied as with a conventional magnetic disk, so that it becomes more difficult for foreign matter to adhere to the cleaning disk. By using a NiP disk onto which no lubricant has been applied as in the present embodiment, it can be ensured that foreign matter present on the magnetic transfer master will adhere to the cleaning disk.

[0042]

As shown in the present embodiment, it is preferable that the cleaning disk 1A is softer than the magnetic transfer master 2. This is because if the surface hardness of the cleaning disk is higher than that of

the magnetic transfer master 2, the following problem occurs. When foreign matter that is harder than the magnetic transfer master 2 but softer than the cleaning disk is present between the cleaning disk and the magnetic transfer master 2, a depression is not formed in the surface of the cleaning disk since the surface of the cleaning disk is harder than the foreign matter. On the other hand, the foreign matter sinks into the surface of the magnetic transfer master 2 that is softer than the foreign matter, thereby causing defects in the magnetic transfer master 2. Such defects, once caused in the magnetic transfer master 2, adversely affect all of the magnetic transfer carried out thereafter.

[0043]

As shown in the present embodiment, the hardness of the cleaning disk surface is lower than that of the magnetic disk surface, so that it is ensured that a depression to be caused by the magnetic disk 1 and the magnetic transfer master 2 can be prevented from occurring in the magnetic disk 1.

[0044]

In the present embodiment, the cleaning disk has a configuration in which a NiP plating layer is applied to an aluminum substrate. However, the plating layer is not limited thereto, and may be one with magnetic characteristics formed of, for example, Co-Re-P, Co-Ni-P, or Co-Ni-Re-P. When a plating layer with magnetic characteristics is applied, the following effect is obtained. That is, when unwanted protrusions are present in the magnetic film present on the surface of the magnetic transfer master 2, there are cases where the repeating pressing and separating operations peel off the magnetic film. However, when there is a plating layer with magnetic characteristics applied to the surface of the cleaning disk 1A, it is ensured that the magnetic layer adheres to the cleaning disk.

[0045]

It is preferable that a region Sa where there is contact between the cleaning disk 1A and the magnetic transfer master 2 is bigger than a region Sb where there is contact between the magnetic disk 1 and the magnetic transfer master 2 and that at least the region Sa includes all of the region Sb. This is because if the magnetic disk 1 contacts the magnetic transfer master 2 in a position beyond the region Sa where cleaning has been performed, there is the risk of foreign matter adhering to the magnetic disk 1.

[0046]

A method of making the region Sa bigger than the region Sb is to use a disk that is larger than the magnetic disk 1 as the cleaning disk 1A.

[0047]

However, in practice there are cases where the cleaning disk and the magnetic disk are manufactured by the same manufacturing apparatus. In such cases, both disks are the same size. Hence, the following method is used to make the region Sa larger than the region Sb.

[0048]

That is, the cleaning disk 1A is placed off-center on the support 6 shown in FIG. 3, and is rotated every time one cycle of the pressing and separating operations is performed. As a result, the position of the cleaning disk 1A relative to the magnetic transfer master 2 progressively changes, so that an area wider than the region Sb (the region where there is contact between the magnetic disk 1 and the magnetic transfer master 2) can be subjected to the suction and pumping.

[0049]

Next, it is examined whether any foreign matter is adhering to surface 3 of the magnetic transfer master 2. As to the examination method, it is extremely difficult to directly detect foreign matter adhering to the surface 3 of the magnetic transfer master 2. The reason is as follows. There are recesses and protrusions forming the grooves 4 and minute recesses and protrusions in the magnetic film 30 at the surface 3 of the magnetic transfer master 2, as shown in FIG. 2. Hence, for example, in an optical examination method, light emitted from a light source is scattered at the edges of such recesses and protrusions, and such places may be mistakenly judged as foreign matter.

[0050]

However, the following method makes it possible to simply and reliably examine whether foreign matter is adhering to the surface 3 of the magnetic transfer master 2.

[0051]

That is, instead of directly examining the surface of the magnetic transfer master 2, the examination as to whether foreign matter is adhering to the surface 3 of the magnetic transfer master 2 is carried out as follows. The magnetic transfer master 2 is pressed against a detection NiP disk, and the surface of the detection NiP disk is examined at which the shape of the

surface of the magnetic transfer master 2 is reflected. The details are described below.

[0052]

First, as shown in step ST3 in FIG. 1, the magnetic transfer master 2 is pressed against and separated from a detection NiP disk 1B only once. The apparatus used for this is one shown in FIGS. 3 and 4 as in step ST2 described above. The difference to step ST2 is that the detection NiP disk 1B is used in place of the cleaning NiP disk 1A. In this case, a softer material than the surface of the magnetic transfer master 2 is used as the surface material of the detection NiP disk 1B. As a result, recesses and protrusions at the surface of the magnetic transfer master 2 are transferred.

[0053]

Next, as step ST4, the surface of the detection NiP disk 1B that was pressed against the magnetic transfer master 2 is examined as to whether there are any defects with a depth that is equal to or greater than a predetermined depth, by an optical examination method, for example, a method of measuring the disk surface having recesses and protrusions, that is, the defects, using the Doppler effect.

[0054]

The shapes of the recesses and protrusions in the surface of the magnetic transfer master 2 have been transferred onto the surface of the detection NiP disk 1B. Since the whole surface of the detection NiP disk 1B is flush and does not have grooves such as those of the magnetic transfer master 2, the scattering of light does not occur during optical measurement. Hence, the examination can be performed properly. By examining the surface, the magnetic transfer master 2 can be examined indirectly.

[0055]

When no defects with a depth equal to or greater than the predetermined depth are found in the examination in step ST4, it is judged that no foreign matter is present on the magnetic transfer master 2. By using this method, a reliable judgment as to whether foreign matter is present on the magnetic transfer master 2 can be made by a simple method.

[0056]

When no defects with a depth equal to or greater than the predetermined depth are found in the examination in step ST4, the magnetic transfer master 2 that was used in step ST3 is used in the step of magnetic transfer in step ST8.

[0057]

When the magnetic transfer master 2 is found to be defective in the examination in step ST4, the magnetic transfer master 2 is subjected to cleaning again in step ST2.

[0058]

As shown in steps ST5 and ST6, the cleaning NiP disk 1A and detection NiP disk 1B are optically examined before being used in the cleaning of the magnetic transfer master 2. Here, it is preferable that a scattered light method is used as the optical examination method. This is because the examination method employing a scattered light method is used, it is especially easy to detect foreign matter on the surface of a disk. The following describes, with reference to FIG. 8, why the optical examination is carried out before cleaning is performed.

[0059]

FIG. 8 is a graph showing the relationship between the number of defects in the surface of a cleaning NiP disk and the number of times the cleaning NiP disk was repeatedly pressed against and separated from a magnetic transfer master 2, with respect to cleaning NiP disks 1A that had been subjected to an optical examination and thereby had been classified into disks with foreign matter present on their surfaces and disks with no foreign matter present on their surfaces.

[0060]

In FIG. 8, the black triangles show the relationship between the defects and the number of times the pressing operation was repeated in the case where foreign matter was present on the surface of the cleaning NiP disk, and the black squares show the relationship between the defects and the number of times the pressing operation was repeated in the case where no foreign matter was present.

[0061]

That is, after the magnetic transfer master 2 and the cleaning NiP disk were pressed together and separated from each other once, an optical examination was performed for the surface of the cleaning NiP disk, and the number of defects was counted. This measurement was made using a disk tester 4218 manufactured by THOT. The number of defects found at this point was taken as an initial value. Since the defects on the magnetic transfer master 2 are transferred onto the cleaning NiP disk at this point, examination performed for the surface of the cleaning NiP disk makes it

possible to ascertain the state of the defects in the magnetic transfer master 2 indirectly.

[0062]

Next, after the magnetic transfer master 2 and the cleaning NiP disk are pressed together and separated from each other a predetermined number of times, the cleaning NiP disk is replaced by a new cleaning NiP disk. After this new cleaning NiP disk and the magnetic transfer master 2 are pressed together and separated from each other once, an optical examination is performed for the surface of the new cleaning NiP disk and the number of defects is counted. This number of defects can be regarded as an indirect indication of the number of defects on the magnetic transfer master 2.

[0063]

From the results shown in FIF. 8, it can be seen that when a cleaning NiP disk with no foreign matter is used, the number of defects on the magnetic transfer master 2 is reduced to zero by the pressing and separating operations that are performed ten times. On the other hand, when a cleaning NiP disk with foreign matter is used, the pressing and separating operations need to be repeated one thousand times to reduce the number of defects to zero.

[0064]

This is to say, when before the cleaning step performed for the magnetic transfer master 2 (ST2 in FIG. 1), an examination is performed for cleaning NiP disks and cleaning NiP disks with no foreign matter are used, the cleaning can be performed efficiently.

[0065]

As shown in step ST6, an examination is performed for the detection NiP disk prior to the pressing operation to prevent, from the start, foreign matter from adhering to the magnetic transfer master due to contact with the detection NiP disk.

[0066]

Next, a method of manufacturing the magnetic disk 1 is described. First, a magnetic layer is formed on the surface using a well-known method. With respect to the formation of the magnetic layer, for example, there is a process of providing a magnetic layer on an aluminum substrate by a dry plating method, such as vapor deposition or sputtering. Conventionally, a method is employed in which the magnetic layer is protected through a

process carried out for forming a protective layer on top of the magnetic layer using dip coating, spin coating, or a dry plating method, such as vapor deposition or sputtering.

[0067]

Next, a step of forming a lubricant layer is carried out, which is a conventional method. In this step, the magnetic disk 1 is immersed in a lubricant solution and then is pulled out at a predetermined speed, whereby the lubricant is applied thereto. By the method described above, the magnetic disk 1 is manufactured.

[0068]

Next, as shown in step ST7, an examination is carried out, by the optical examination method, to detect whether foreign matter is present on the surface of the magnetic disk 1. Here, it is preferable to use a scattered light method as the examination method. A scattered light examination method is a method that is suitable for detecting foreign matter on the surface of a disk. Hence, in order to definitely remove any foreign matter immediately before the magnetic transfer that follows this step, this method preferably should be used. Naturally, another method may be employed in which an existing magnetic disk 1 is taken and the optical examination is carried out in step ST7.

[0069]

Next, magnetic transfer in step ST8 is performed. The details are described with reference to FIGS. 9 and 10. The configuration of magnetic transfer is almost the same as that shown in FIG. 3. FIG. 9 shows a step of separating the magnetic transfer master 2 and the magnetic disk 1 during the magnetic transfer. FIG. 7 shows the relationship between the passage of time and the air pressure in the space (hereafter referred to as a “space S”) between the magnetic transfer master 2 and the magnetic disk 1 during the above-mentioned step. In FIG. 7, the air pressure in the space S sharply increases from a pressure of 101.3 kPa after the lapse of about 3 seconds, and thereafter, a pressure of about 130 kPa is maintained for about one second. This period corresponds to the above-mentioned state where the magnetic transfer master 2 and the magnetic disk 1 are separated from each other. Next, a step of pressing by suction is described with reference to FIG. 10.

[0070]

The air supplying pump 12 is stopped and the air supplying valve 13

is closed. As a result, the holding arm 14 to which the magnetic disk 1 is attached moves downward due to its own weight, and it is placed on the magnetic disk 1 with the boss 5 engaging the center hole of the magnetic disk 1. After this, the exhaust valve 11 is opened and the exhaust pump 10 is operated. As a result, air in the through hole 7 is expelled downwards as shown by the arrow C in FIG. 10. Thus, the air in the grooves 4, which is to say the air in the gap S, also is expelled through the gap between the center hole of the magnetic disk 1 and the boss 5.

[0071]

As a result, the magnetic disk 1 and the magnetic transfer master 2 are pressed together by their entire circumferences, and the pressure becomes lower than atmospheric pressure. Hence, the magnetic disk 1 is pressed onto the magnetic transfer master 2 by the atmospheric pressure 15.

[0072]

In FIG. 7, the period during which the air pressure in the space S is about 30 kPa corresponds to the above-mentioned pressing state.

[0073]

Next, as shown in FIG. 10, the magnet 20 is moved in the direction shown by the arrow D and so approaches the magnetic transfer master 2. When the magnet 20 is 1 mm away from the magnetic transfer master 2, its movement in the direction shown by the arrow D is stopped. Next, the magnet 20 is moved at least once around the circumference of the magnetic disk 1 in its circumferential direction, which is to say in the direction shown by the arrow E, thereby applying the magnetic field required for transfer.

[0074]

After this, the separation process shown in FIG. 9 is repeated to separate the magnetic transfer master 2 and the magnetic disk 1 from each other.

[0075]

Next, step ST9 is described with reference to FIG. 11. FIG. 11 is a perspective drawing that illustrates an apparatus for performing a glide height test in the present embodiment of the present invention.

[0076]

A glide height test is a test where a detection head scans the magnetic disk, and defects in the magnetic disk are detected through detection of an impact by the detection head. When performing this test,

the clearance between the detection head and the magnetic disk is set slightly smaller than the clearance used when a magnetic head actually scans the magnetic disk.

[0077]

The apparatus shown in FIG. 11 includes: a spindle 21 for supporting and rotating the magnetic disk 1 that has been subjected to step ST8 (magnetic transfer); a clamp mechanism 22 that attach the magnetic disk 1 to the spindle 21; a head supporting mechanism 23 provided with a glide height test head slider 40; a guide arm 24 that supports the head supporting mechanism 23 at its base in the form of a cantilever, with an acoustic emission sensor 25 being attached thereto; a head positioning unit 26 that moves the head 40 by moving the head supporting mechanism 23 and the guide arm 24 above the recording surface of the magnetic disk 1 to position the head 40; a positioning control unit 27 that controls the operation of the head positioning unit 26; a spindle control unit 28 that controls the operation of the spindle 21; and a controller 29 that controls the positioning control unit 27 and spindle control unit 28.

[0078]

First, the controller 29 lets the spindle control unit 28 rotate the magnetic disk 1 at a predetermined speed. Next, the head positioning unit 26 is controlled by the positioning control unit 27 so as to move in the direction F shown in FIG. 11 and to stop when there is a predetermined distance, which is to say 15 nm, between the magnetic disk 1 and the head 40. This position setting method is described as follows.

[0079]

When the head positioning unit 26 is in a certain position, the distance between the magnetic disk 1 and the head 20 is measured. The distance by which the head positioning unit 26 needs to move to allow the distance between the magnetic disk 1 and the head 40 to be 15 nm is then calculated and stored in the controller 29. The controller 29 lets the positioning control unit 27 move the head positioning unit 26 and so sets the distance between the magnetic disk 1 and the head 40 at 15 nm. The distance between the magnetic disk 1 and the head 40, which is to say 15 nm, is set at a value that is equal to or slightly lower than the distance a magnetic head floats above the magnetic disk 1 during recording and reproduction in an actual apparatus.

[0080]

Thereafter, while the magnetic disk 1 is being rotated, the head 40 is controlled by the positioning control unit 27 so as to move in the direction G shown in FIG. 11, which is to say in the radial direction of the magnetic disk, to perform a glide height test for at least the surface that came into contact with the magnetic transfer master 2 during the magnetic transfer performed in step ST8.

[0081]

By doing so, unwanted protrusions present on the surface of the magnetic disk 1, and in particular protrusions that are at least as high as the clearance provided between the magnetic disk and a magnetic head during recording and reproduction, are detected by the acoustic emission sensor 25, based on excessive vibrational energy produced upon collisions. Thus, the presence of unwanted protrusions are detected. Here, when at least one unwanted protrusion is present in one magnetic disk 1, the disk is judged to be defective, and the cleaning of the magnetic transfer master 2 is started as shown in step ST2 in FIG. 1.

[0082]

When no unwanted protrusions are detected, the disk is judged to be OK, and the following step, step ST10, is performed.

[0083]

Step ST10 is a step of examination to detect defects on the surface of the magnetic disk 1. The defect detection is performed optically with respect to the surface of the magnetic disk 1. When defects are found by this examination, the cleaning of the magnetic transfer master 2 is started in step ST2 as shown in FIG. 1. When no defects are found, the magnetic disk 1 is installed in a hard disk drive.

[0084]

Using the following method, it is judged whether foreign matter has adhered to the magnetic transfer master 2 while a step of magnetic transfer is being performed repeatedly. An examination is performed to detect defects in the surface of the magnetic disk 1 after the magnetic transfer, the magnetic transfer master is cleaned when defects are found, and then the examination is performed again. This method makes it possible to quickly and easily judge whether foreign matter is adhering to the magnetic transfer master 2, and to remove the foreign matter. Thus, highly reliable magnetic transfer can be achieved.

[0085]

As described above, according to the present embodiment, the following cleaning method is employed. A disk whose surface has been subjected to optical examination to confirm that it has no foreign matter is pressed against and separated from a magnetic transfer master and thus cleaning is performed. In this way the magnetic transfer master can be cleaned reliably in an efficient manner.

[0086]

Furthermore, the present embodiment employs the method in which the judgment as to whether foreign matter has been removed from the surface of the magnetic transfer master is made through the examination carried out for the disk after the pressing operation. Hence, the extent to which the master disk should be washed can be judged simply and correctly.

[0087]

According to the present embodiment, using the following method, it is judged whether foreign matter is adhering to the magnetic transfer master 2 while the step of magnetic transfer is being performed repeatedly. An examination is performed to detect defects in the surface of the magnetic disk 1 after magnetic transfer, and the magnetic transfer master is cleaned when defects are found, and then the examination is carried out again. By using this method, it becomes possible to quickly and easily judge whether foreign matter is adhering to the magnetic transfer master 2, and to remove the foreign matter. Hence, highly reliable magnetic transfer can be achieved.

[0088]

The embodiment of the present invention employs the method in which step ST2 is carried out after the magnetic transfer master 2 is washed. However, the effect obtained when the magnetic transfer master 2 is cleaned still can be exhibited well even if step ST1 is omitted and the processing instead starts from step ST2.

[0089]

Also, steps ST2 and ST8 may be performed in the same apparatus.

[0090]

Furthermore, the embodiment of the present invention employs the method in which the magnetic transfer master 2 and the magnetic disk 1 are aligned using the boss 5. However, the method is not the only one. For instance, a movable stage may be provided on the holding arm 14 that holds the magnetic transfer master 2 and an optical method may be used to

align the magnetic disk 1 and the magnetic transfer master 2.

[0091]

[Effects of the invention]

As described above, according to the present invention, the following cleaning method is employed. A disk whose surface has been subjected to optical examination to confirm that it has no foreign matter is pressed against and separated from a magnetic transfer master and thus cleaning is performed. In this way the magnetic transfer master can be cleaned reliably in an efficient manner.

[0092]

Furthermore, the present embodiment employs the method in which the judgment as to whether foreign matter has been removed from the surface of the magnetic transfer master is made through the examination carried out for the disk after the pressing operation. Hence, the extent to which the master disk should be washed can be judged simply and correctly.

[0093]

According to the present embodiment, using the following method, it is judged whether foreign matter is adhering to the magnetic transfer master 2 while the step of magnetic transfer is being performed repeatedly. An examination is performed to detect defects in the surface of the magnetic disk 1 after magnetic transfer, and the magnetic transfer master is cleaned when defects are found, and then examination is carried out again. By using this method, it becomes possible to quickly and easily judge whether foreign matter is adhering to the magnetic transfer master 2, and to remove the foreign matter. Hence, highly reliable magnetic transfer can be achieved.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[FIG. 1]

A flowchart showing steps of magnetic transfer performed according to an embodiment of the present invention.

[FIG. 2]

An enlarged view of part of a magnetic transfer master, which is used for explaining the configuration of the magnetic transfer master according to the embodiment of the present invention.

[FIG. 3]

A cross-sectional drawing showing an apparatus, showing step ST2 according to the embodiment of the present invention.

[FIG. 4]

A cross-sectional drawing showing an apparatus, showing step ST2 according to the embodiment of the present invention.

[FIG. 5]

A drawing showing a contact surface of the magnetic transfer master that comes into contact with the cleaning NiP disk according to the embodiment of the present invention.

[FIG. 6]

A detailed drawing of a boss according to the embodiment of the present invention.

[FIG. 7]

A graph showing the relationship between the passage of time and air pressure in a space S according to the embodiment of the present invention.

[FIG. 8]

A graph showing the relationship between the number of times a pressing operation is repeated and the number of defects in the surface of the magnetic disk according to the embodiment of the present invention.

[FIG. 9]

A drawing showing steps of magnetic transfer according to the embodiment of the present invention.

[FIG. 10]

A drawing showing steps of magnetic transfer according to the embodiment of the present invention.

[FIG. 11]

A perspective view illustrating an apparatus for performing a glide height test according to the embodiment of the present invention.

[FIG. 12]

A view showing a result of observation of the magnetic disk surface after magnetic transfer according to a conventional method.

[FIG. 13]

A cross-sectional view of a depression in the magnetic disk according to the conventional method.

[FIG. 14]

A depiction showing results of measurement carried out for the surface of the magnetic disk after the magnetic transfer by an optical measurement method according to the conventional method.

[Explanation of letters or numerals]

1 magnetic disk

1A cleaning NiP disk

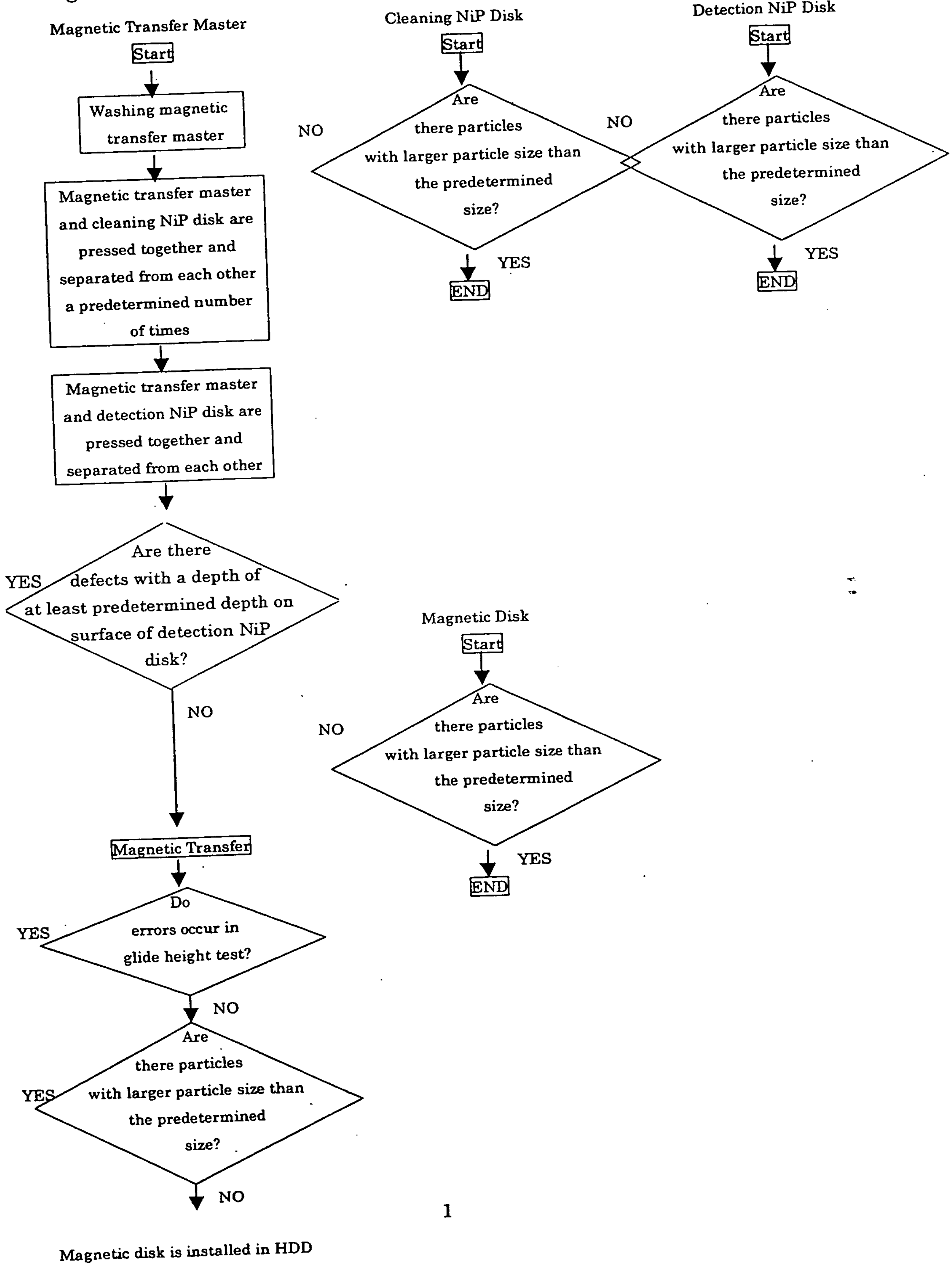
1B detection NiP disk

2 magnetic transfer master

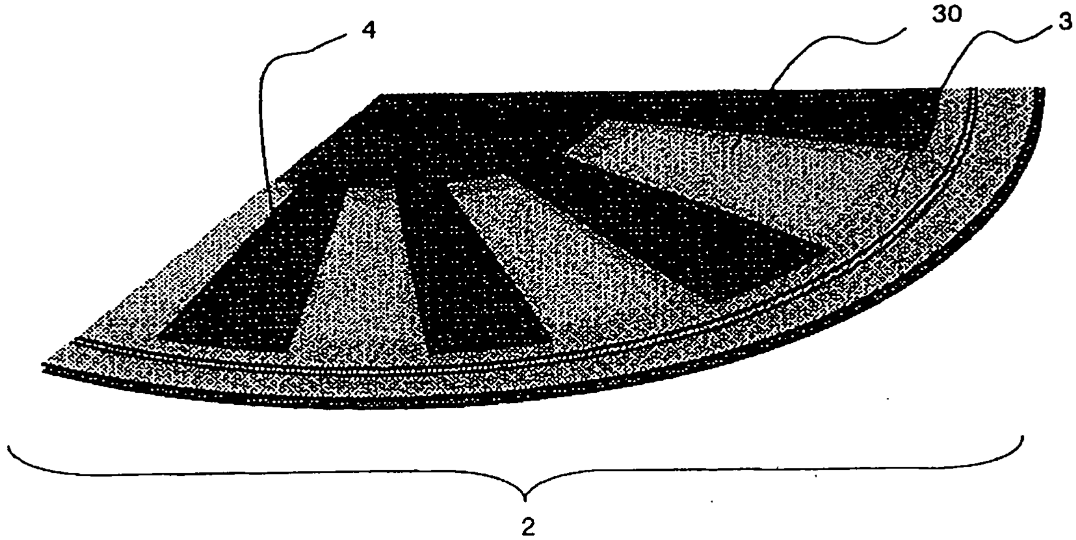
3 transfer surface of master

【Document Name】 Drawings

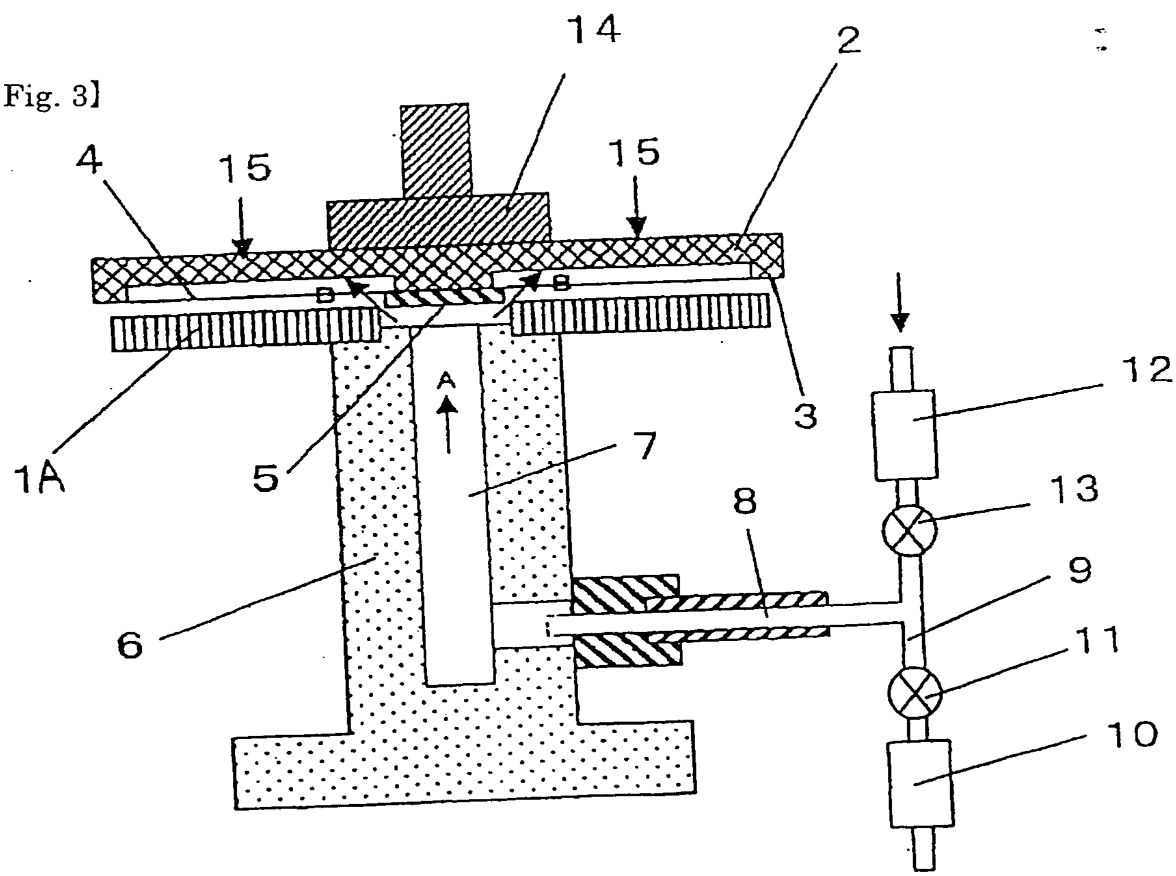
【Fig. 1】



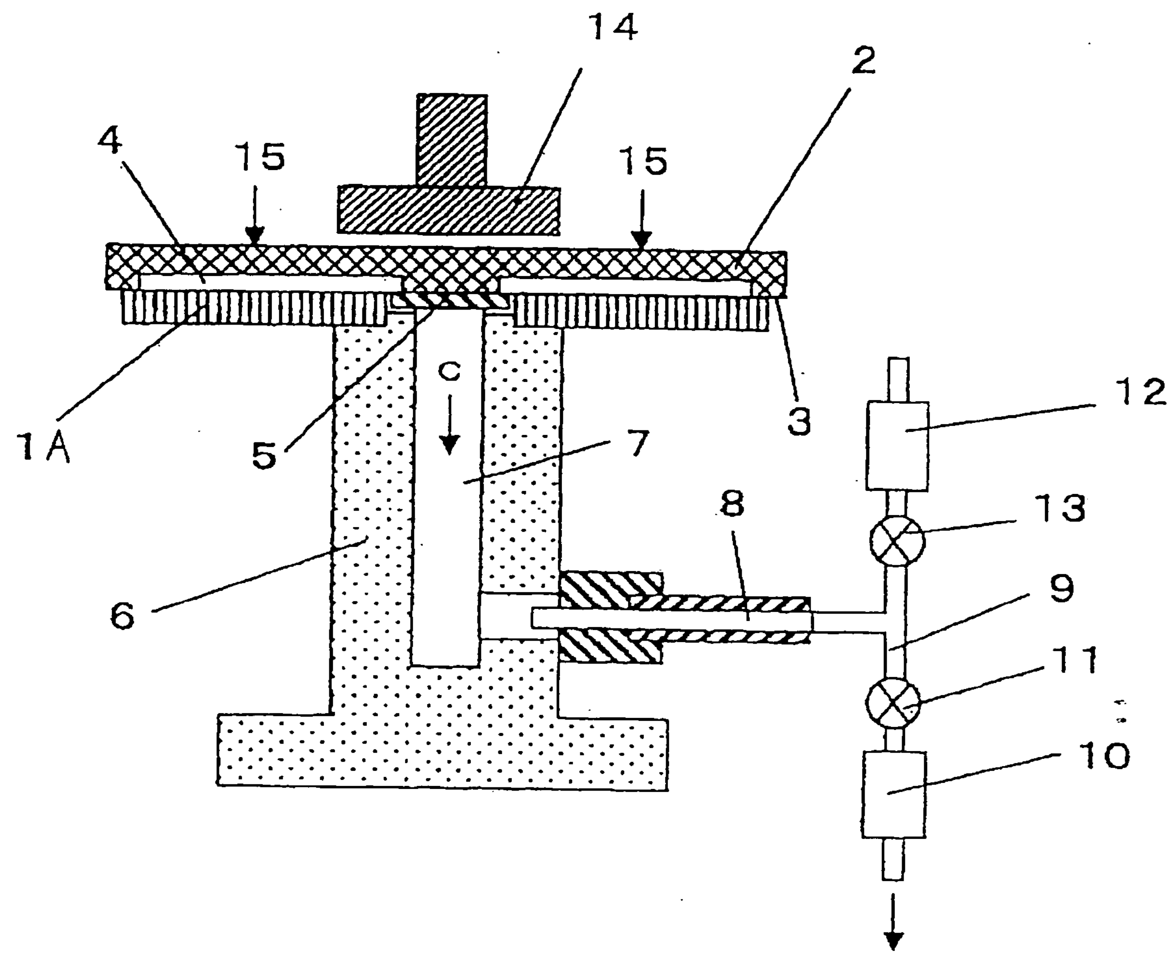
【Fig. 2】



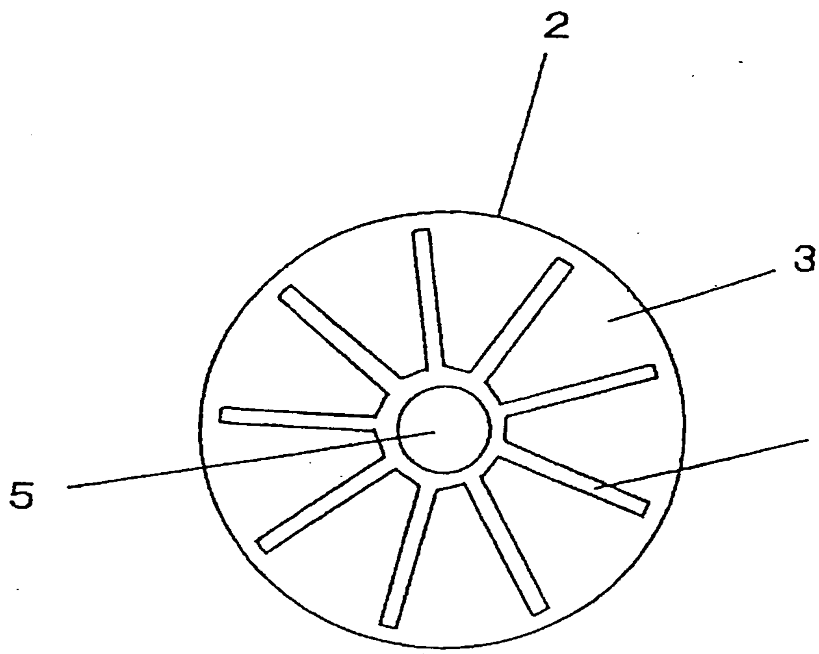
【Fig. 3】



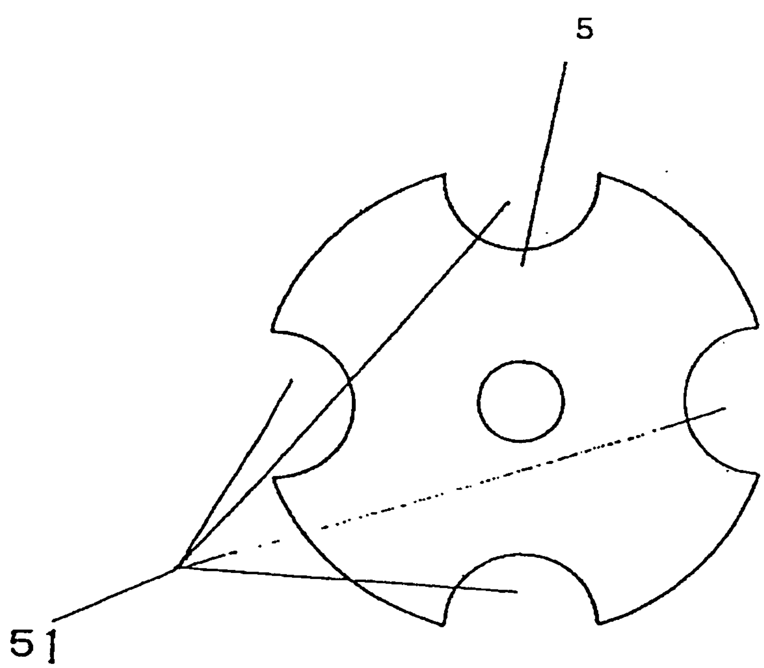
【Fig.4】



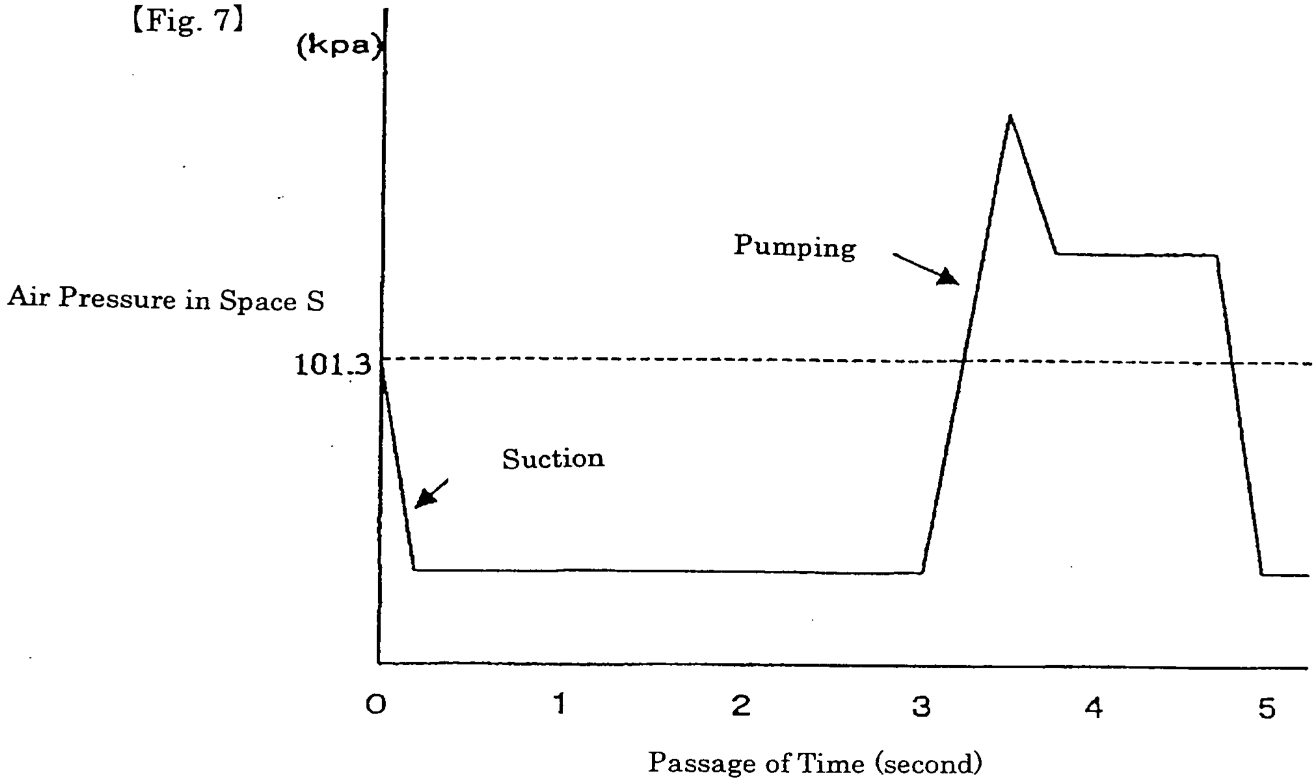
【Fig. 5】



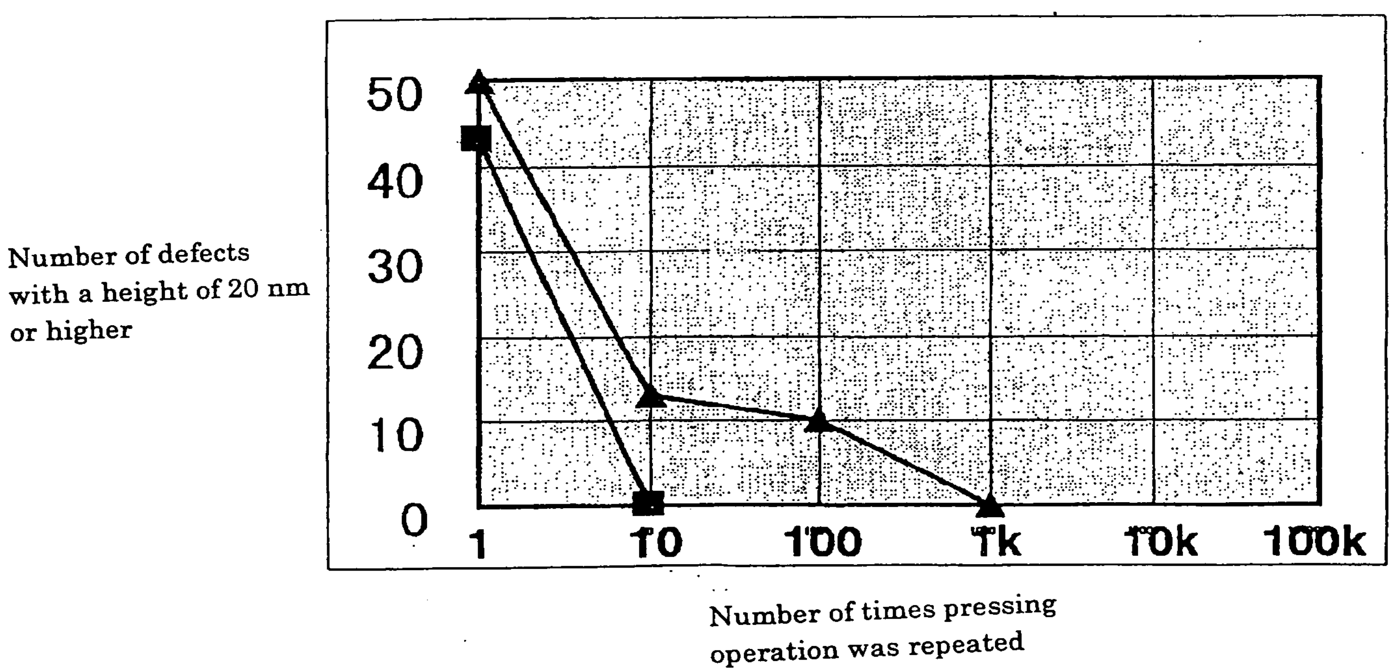
【Fig. 6】



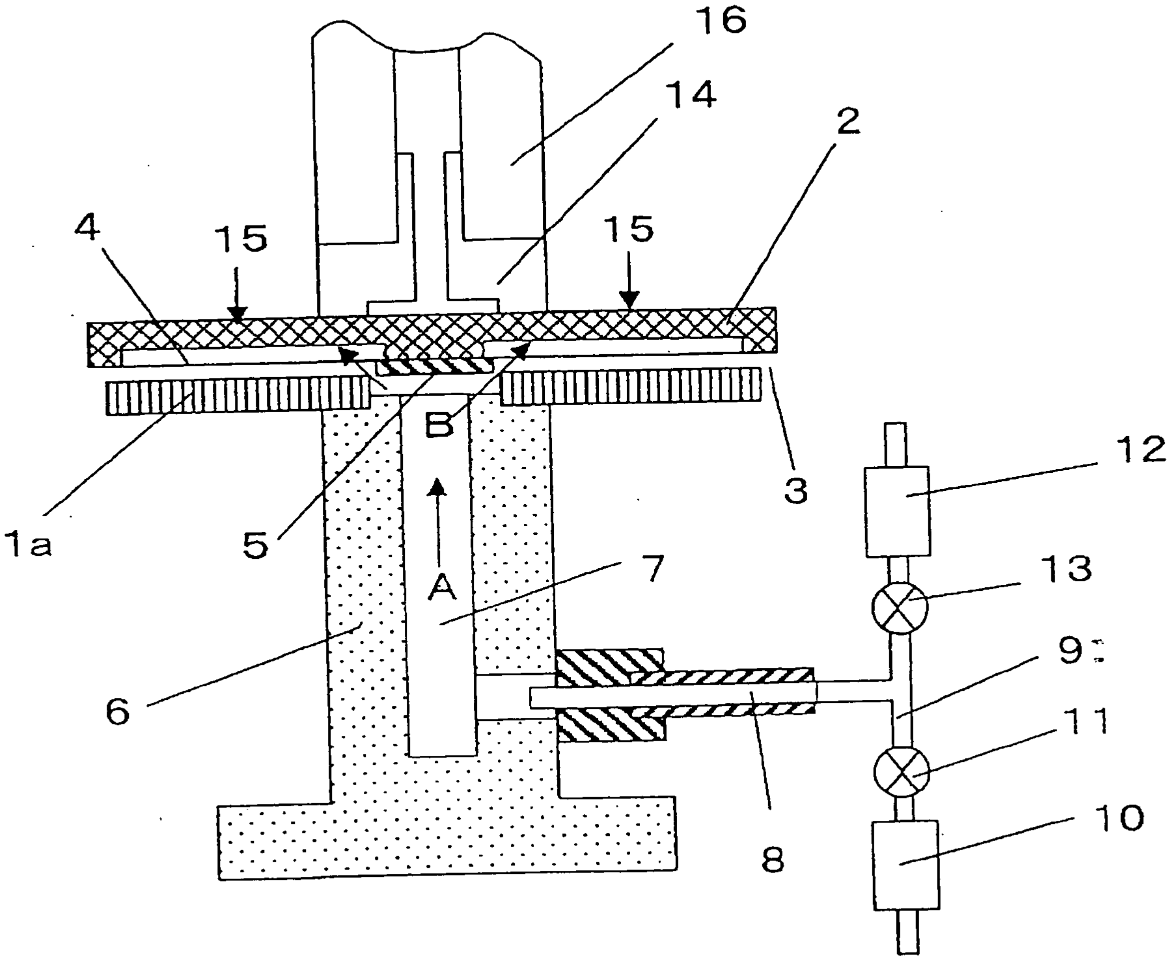
【Fig. 7】


(kpa)
Air Pressure in Space S
101.3
Pumping
Suction
0
1
2
3
4
5
Passage of Time (second)

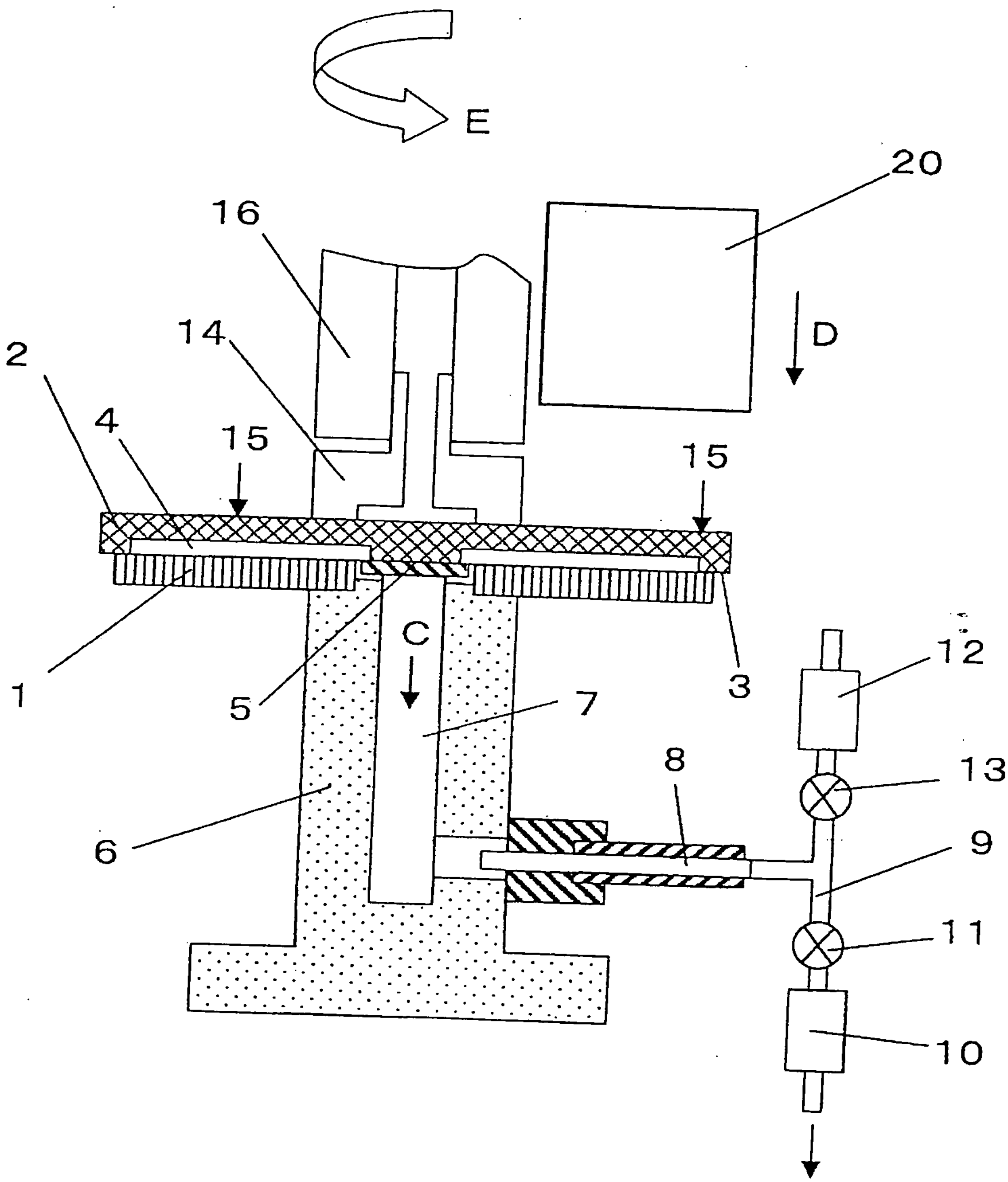
【Fig. 8】


Number of defects with a height of 20 nm or higher
50
40
30
20
10
0
1
10
100
1k
10k
100k
Number of times pressing operation was repeated

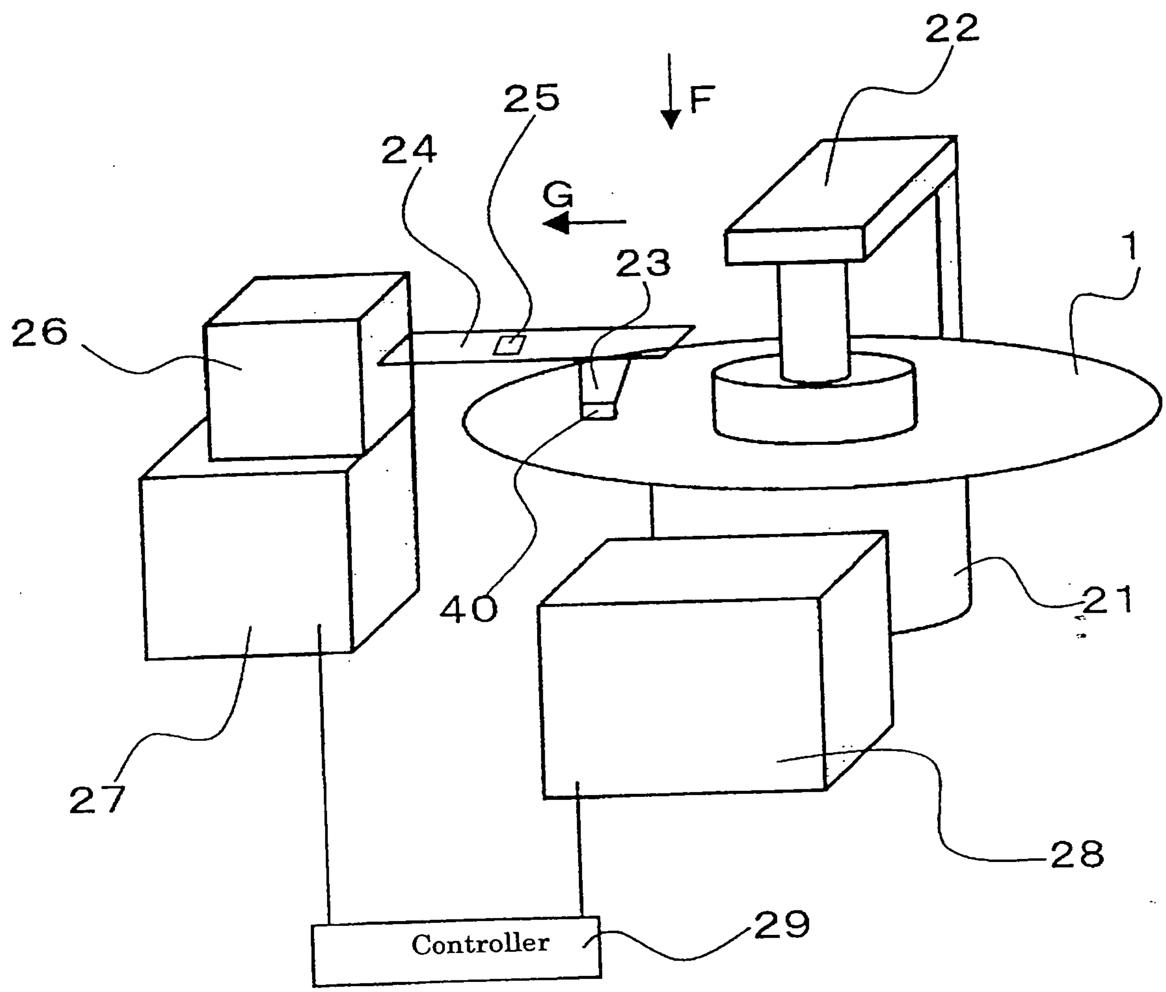
【Fig. 9】



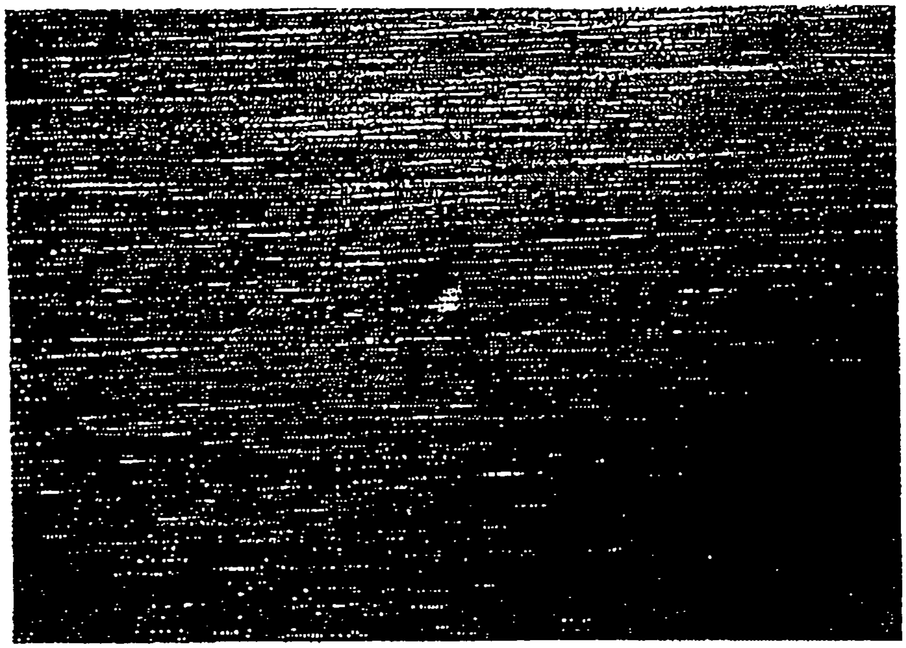
【Fig. 10】



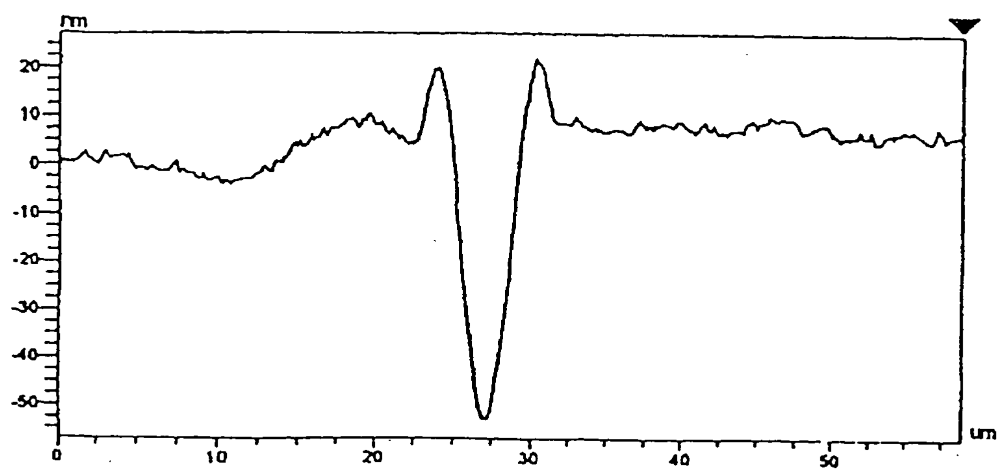
【Fig. 11】



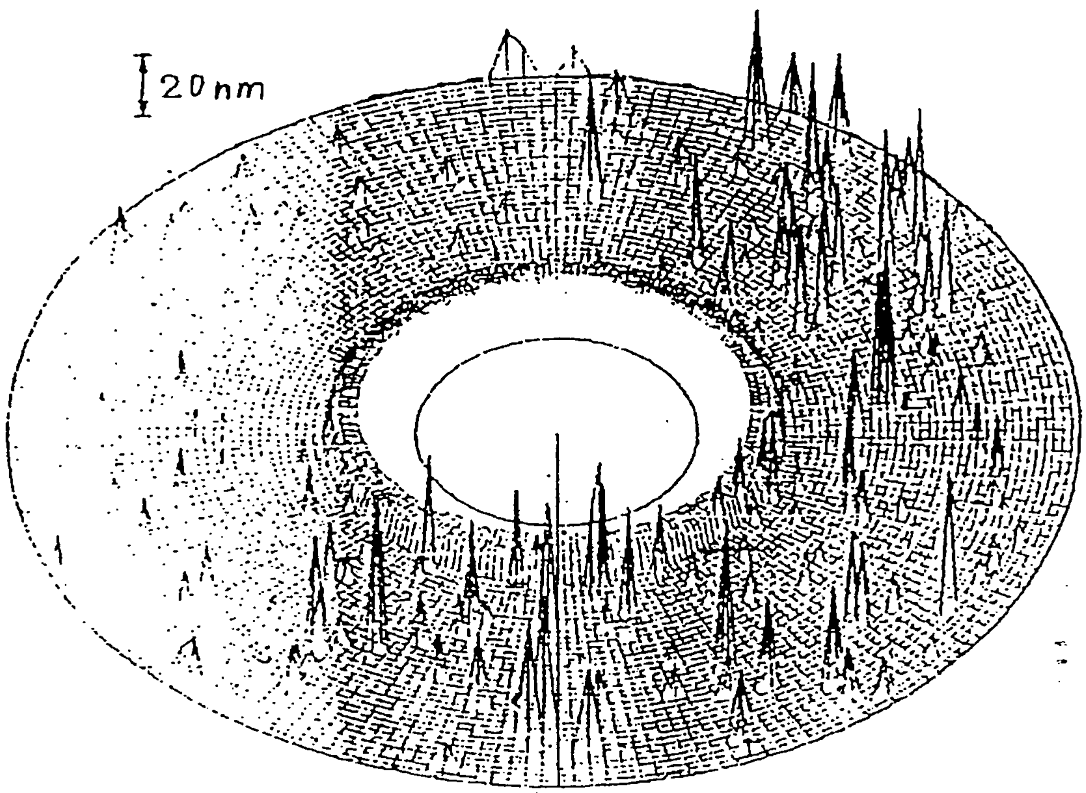
【Fig. 12】



【Fig. 13】



【Fig. 14】



[Document Name] ABSTRACT

[Abstract]

[Problems] Minute protrusions are produced in a magnetic disk due to the contact between the magnetic disk and a magnetic transfer master.

[Means to Solve the Problems] A cleaning disk with no foreign matter present on its surface is brought into close contact with a magnetic transfer master repeatedly, and thereby foreign matter on the surface of the magnetic transfer master can be removed reliably.

[Selected Figure] FIG. 1